DOE: Joint Hydrogen Storage Tech Team Meeting (August 25, 2016)

Barry Meneghelli, Ph.D
Cryogenics Test Laboratory
VENCORE
Kennedy Space Center, Fl
Barry.j.meneghelli@nasa.gov

The ***Cryogenics Test Laboratory, NASA Kennedy Space Center***, is a unique community for research, development, and application of cross-cutting technologies to meet the needs of industry, government, and research institutions.

Technology focus areas include:

- ✓ *Thermal insulation systems*
- ✓ *Integrated refrigeration systems*
- ✓ *Advanced propellant transfer systems*
- ✓ *Novel components and materials*
- ✓ *Low-temperature applications*

Cryogenics is about two things:

1) using low-temperatures to do something useful,

2) storing something in a small space (energy density).

Connections

- ✓ Florida Academics: UCF, FTU, USF, UF, FSU, and ERAU
- ✓ Federal Agencies: DoD, DoE, DHS
- ✓ National Institute of Standards (NIST): Boulder and Gaithersburg
- ✓ National Laboratories: Oak Ridge, Jefferson, Fermilab, Los Alamos, Livermore
- ✓ NASA Centers: MSFC, GRC, LaRC, GSFC, JSC, SSC, ARC, JPL, WSTF
- ✓ Industry Partners: Aerospace; General Industry; High Energy Physics
- ✓ Cryogenic Society of America (CSA)
- ✓ Cryogenic Engineering Conference (CEC) and International Cryogenics Materials Conference (ICMC)
- ✓ Space Cryogenics Workshop (SCW)
- ✓ International Cryogenic Engineering Conference (ICEC)
- ✓ International Institute of Refrigeration (IIR)
- ✓ American Institute of Aeronautics and Astronautics (AIAA)
- ✓ ASTM International (ASTM)
- ✓ International Standards Organization (ISO)

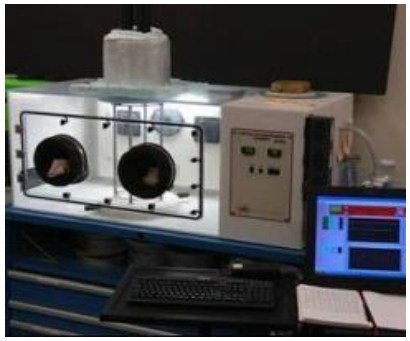
Success in cryogenics has always been defined as a healthy triangle of interaction among research, industry, and training.

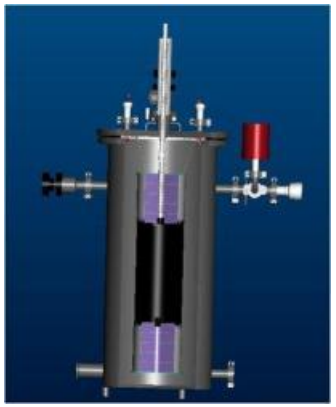
Technical Consensus Standards for Thermal Insulation Systems

- To help meet the today's needs and further the possibilities for future gains in *global energy efficiency*, cryogenic insulation standards are being developed.
- Under ASTM International's Committee C16 on Thermal Insulation, two new standards were published in 2014:
  - ASTM C1774 - *Standard Guide for Thermal Performance Testing of Cryogenic Insulation Systems*
  - ASTM C740 – *Standard Guide for Evacuated Reflective Insulation in Cryogenic Service*

Cryostat Insulation Test Instruments

- Cryostat-100, Cylindrical – Absolute
- Cryostat-200, Cylindrical – Comparative
- Cryostat-400, Flat Plate – Comparative
- Cryostat-500, Flat Plate – Absolute
- Macroflash (Cup Cryostat), Flat Plate - Comparative
- Cryogenic Moisture Uptake Apparatus
- Transient Thermal Tester
- 1000-liter Tank Cryostat (LH_2 or LN_2)
- Cryogenic Pipeline Test Apparatus
- Patents:
  - *Methods of Testing Thermal Insulation and Associated Test Apparatus,* US Patent 6,742,926
  - *Multi-purpose Thermal Insulation Test Apparatus,* US Patent 6,487,866
  - *Thermal Insulation Testing Method and Apparatus,* US Patent 6,824,306
  - *Insulation Test Cryostat with Lift Mechanism,* US Patent 8,628,238 B2
  - Thermal Insulation Testing Method and Apparatus, US Patent 6,824,306
  - Insulation Test Cryostat with Lift Mechanism, US Patent application, US20140079089 A1
  - Additional patents pending





DOE Award

- Integrated Insulation System for Automotive Cryogenic Storage Tanks (*i*CAT)
  - Partners
    - NASA
    - Aspen Aerogels
    - Hexagon Composites (formerly Hexagon Lincoln)
    - Savannah River National Laboratories (SRNL)
  - Major Goal
    - Development of an integrated subscale insulation system prototype demonstrating the DOE 5-7 W heat leak targets for a 100 L cryogenic hydrogen storage tank

DOE Award

Additional Project Goals

- Minimized solid conduction through novel structural supports
- Improved system robustness to dampen vibration and shock
- Layered composite insulation with integral getters for moderate vacuum level
- Stabilized vessel vacuum levels using composite tank materials, processes or treatments
- Development of industry standards and protocols
- Computational and experimental demonstration of an integrated insulation system
- Predictive insulation design model capabilities beyond the current project effort

DOE Award

Summary

- Three-pronged approach of ***isolation, insulation, and integration (i^3)*** to address the structural, thermal, and vacuum aspects of the system.
  - ISOLATION
    - Penetrations, Sensors, feedthroughs
    - Vibration, acceleration, shock loads
    - Ease of manufacturing
  - INSULATION
    - Layered composites
    - Vacuum level considerations
  - INTEGRATION
    - Film coatings on the pressure vessel
    - Manufacturing process development
    - Adsorbents and getters